

### 5.3 INDICATOR ~~CHEMICALS~~ ~~CONTAMINANTS~~ IN MOBILE SEDIMENT SEDIMENT TRAPS

This section ~~discusses mobile sediment at Portland Harbor by summarizing~~es the sediment trap data ~~for the LWG rounds of~~collected for this investigation. ~~The sediment trap investigation was designed to capture anticipated spatial and temporal variability of suspended sediment mass, fill data gaps related to the nature and extent of potential sources, and support the preparation of the BERA (Anchor 2006c).~~ The geographic locations of all sediment trap stations are presented on Map 2.1-242-3.

Discussion of the ICs addressed in this section focuses primarily on the following elements:

- A description of the data set for each contaminant, including frequency of detection and concentration range
- The sampling locations and periods (sampling quarters) with elevated contaminant concentrations and any apparent spatial or temporal gradients among the data set
- An evaluation of contaminant concentrations found in the Study Area compared to concentrations found at locations outside of the Study Area

The following subsections present histograms and stacked bar charts to support discussion and evaluation of the nature and extent of ~~selected the~~ ICs. Additional tabular and graphical summaries of the sediment trap data set are included in Appendix D2.

~~The primary purpose of sediment trap sampling was to gather data for the evaluation of FS alternatives (Anchor 2006c). In addition, the sediment trap investigation was designed to capture anticipated spatial and temporal variability of suspended sediment mass, fill data gaps related to the nature and extent of potential sources, and support the preparation of the BERA (Anchor 2006c). The chemistry distributions for the sediment traps are depicted graphic in histograms showing IC concentrations for each location and grouped by sampling quarter (Figures 5.3-6, 5.3-7, and 5.3-9 through 5.2-21). The blank spaces in the histograms within station groups signify that the volume of material collected for the quarter was not sufficient for analysis or the sediment trap was lost. Sample analyses resulting in non-detects are flagged in the histograms to distinguish them from cases where results are not available. Scales for IC concentrations (y-axis) were selected to emphasize higher concentrations yet visually distinguish comparatively low concentrations. In some cases, values above scale maximums are labeled with the sample concentration.~~

Other graphic displays used to assist with data interpretation include two scatter plots (Figures 5.3-3 and 5.3-8) with regression lines to fit the data and accompanying regression equations. Natural log-transformed PCB congener concentrations are

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regressed on natural log-transformed Aroclor concentrations in Figure 5.3-8 to display the relationship between PCB results obtained using different analytical methods. The relationship between sediment accumulation rates and the percentage of fines (i.e., silt and clay, particles  $\leq 62 \mu\text{m}$ ) is shown in a scatter plot of the un-transformed data sets (Figure 5.3-3). Plots of sample grain size distribution are shown in Figure 5.3-4. A line graph (Figure 5.3-1) is used to display the Willamette River daily discharge hydrograph for the entire sediment trap sampling period, with quarterly sampling periods identified by different colors. This hydrograph also displays average historical daily discharges for a 36-year period (1972–2008). Figure 5.3-5 shows the quarterly distribution of the daily Willamette River discharge combined with sediment accumulation rates (also depicted in Figure 5.3-2), and percent fines (also depicted in Appendix D2.1, Figure D2.1-22).

### 5.3.1 Mobile Sediment Trap Data Set

This section focuses on the concentrations of ~~15~~ ICs associated with samples from in-river sediment trap samples collected within the Lower Willamette River.

Sediment traps were deployed at 16 locations in the Lower Willamette River from late 2006 through late 2007 (see Map 2.2-3). Twelve of the locations were within the Study Area between RM 1.9 and 11.5. One sediment trap was deployed just downstream of the Study Area at RM 1.8, two were located just upstream of Ross Island at RM 15.6 and 15.7, and one was located in Multnomah Channel. Paired sediment traps were deployed and maintained on opposite sides of the river at approximately RM 1.9, 6, 11.5, and 15.7. Samples were retrieved quarterly to obtain four quarters (1 year) of data. A total of 52 sediment trap samples were collected and analyzed per the protocols used in Rounds 2A and 2B; some samples were not obtained due to lack of material in the trap or loss of the trap.

In June 2009, seven sediment traps were deployed by the City of Portland between RM 11 and 12.1 (Map A??) to characterize settleable suspended sediments deposited in this area of the river during Quarters 3 and 4 of 2009 (GSI 2010). A total of 134 samples were collected and analyzed from this sampling event; one sediment trap (ST007) was not recovered during Quarter 4.

These samples were analyzed to measure the sediment trap mass accumulation and concentrations of sediment-bound contaminants that enter the Study Area from upstream sources, contaminant concentrations associated with regional sources within the Study Area, and concentrations of sediment-bound contaminants that migrate downstream from the Study Area. Additional information on the Lower Willamette River hydrology, sediment accumulation, and the role of fine sediments provided to aid with interpretation of the chemical data, is presented in Figures 5.32-1 through 5.32-5. Distributions of ~~selected the ICs and patterns of bounding ICs—total PCBs, total PCDD/Fs, total DDXs, and total PAHs—~~ are shown in Figures 5.32-6 through 5.32-210 and 5.2-14 through 5.2-30, and are summarized in Tables 5.23-1 through 5.23-47.

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Figures 5.2-11 through 5.2-13 present an analysis of PCB homolog data across all stations; details of this analysis are discussed in Section 5.2.5.

## 2.0.0 Indicator Chemicals in Sediment Traps

The IC list for sediment is presented in Table 5.0-2. A total of 34 individual analytes and calculated analyte sums were identified as ICs for bedded sediment in Section 5.1. Specific chemicals and chemical sums selected as ICs for sediment traps were identical to those selected for sediments, with one exception: total PCB Aroclors and total PCB congeners are presented separately in this section, whereas total PCBs in Section 5.1 were evaluated in a single presentation (i.e., total Aroclors were selected when total PCB congeners were not available). The ICs for sediment identified below pose the most widespread or significant potential risks to human health or the environment in Portland Harbor Study Area sediment; however, other contaminants present and comingled throughout the Study Areas may also pose risk. Additional discussion of the identification and use of the ICs in the RI and their relation to contaminants with potentially unacceptable risk in the baseline risk assessments and FS is presented in the introduction of Section 10.

The ICs for sediment traps are organized as follows:

- PCBs
  - Total Aroclors\*
  - Total PCB Congeners\*
  - PCB TEQ (ND=0)
- PCDD/Fs
  - Total PCDD/Fs\*
  - TCDD TEQ (ND=0)\*
- Total DDx
  - Total DDx (2,4'- and 4,4'-DDD, DDE, DDT)\*
  - Total of 2,4'- and 4,4'-DDT
  - Total of 2,4'- and 4,4'-DDE
  - Total of 2,4'- and 4,4'-DDD
- PAHs
  - Total PAHs\*
  - Total LPAHs
  - Total HPAHs
  - Total ePAH BaPEq values

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~~Phenanthrene~~  
~~Naphthalene~~  
~~BAP~~  
● ~~Petroleum Hydrocarbons~~  
~~TPH~~  
~~TPH - DRH~~  
~~TPH - RRH~~  
● ~~SVOCs~~  
~~BEHP\*~~  
~~Butylbenzyl phthalate~~  
~~PCP~~  
~~Hexachlorobenzene~~  
● ~~Pesticides~~  
~~Total chlordanes\*~~  
~~gamma HCH~~  
~~Aldrin\*~~  
~~Dieldrin\*~~  
● ~~Organometallic Compounds~~  
~~TBT\*~~  
● ~~Metals~~  
~~Arsenic\*~~  
~~Cadmium~~  
~~Chromium\*~~  
~~Copper\*~~  
~~Lead~~  
~~Mercury~~  
~~Nickel~~  
~~Zinc\*~~

Fourteen of the ICs, which are indicated with an asterisk (\*) in the above list, are discussed in this section (total PCDD/Fs and TCDD TEQ are grouped as one chemical in this count). As

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indicated in Section 5.1, although numerous contaminants that potentially pose risk to human health or the environment are comingled across the site, 13 ICs were selected for sediments, in consultation with EPA, to match the contaminants identified for the site-wide CSM (Section 10). In this section, PCB congeners and PCB Aroclors are described separately, bringing the total up to 14. The remaining ICs are not discussed in this section, but their concentrations, as well as percent fines and TOC, in sediment traps are displayed graphically in Appendix D2.1 (see Figures D2.1-1 through D2.1-23).

Discussion of the ICs addressed in Section 5.2 focuses primarily on the following elements:

- A description of the data set for each analyte, including frequency of detection and concentration range
- The sampling locations and periods (sampling quarters) with elevated analyte concentrations and any apparent spatial or temporal gradients among the data set
- An evaluation of analyte concentrations found in the Study Area compared to concentrations found at locations upstream of the Study Area
  - Brief comparisons between analyte concentrations in east-west paired samples.

As noted previously, the bounding ICs—total PCBs, total PCDD/Fs, total DDX, and total PAHs—are discussed in more detail. Patterns in the relative abundance of each contaminant's components (e.g., homologs, isomers) are examined to evaluate the potential for source identification among spatial and temporal dimensions.

### 5.3.1 Description of Sediment Trap Presentation Tools

The sediment trap chemistry distributions are depicted in several graphic display formats. The two primary graphical formats are in histograms showing IC concentrations for each location and grouped by sampling quarter (Figures 5.23-6, 5.3-7, 14, 16, 17, 19, and 5.23-229 through 5.2-3021), and stacked bar charts depicting patterns of bounding ICs (Figures 5.2-9, 10, 15, 18, 20, and 5.2-21).

The blank spaces in the histograms within station groups signify that the volume of material collected for the quarter was not sufficient for analysis or the sediment trap was lost. Sample analyses resulting in non-detects are flagged in the histograms to distinguish them from cases where results are not available. Scales for IC concentrations (y axis) were selected to emphasize higher concentrations yet visually distinguish comparatively low concentrations. In some cases, values above scale maximums are labeled with the sample concentration.

Stacked bar charts are designed to reveal potentially distinctive patterns in the relative abundance of bounding IC components. These graphs provide a line showing concentrations of the IC (i.e., totals) on a logarithmic scale, but do not display concentrations of the analyte components (e.g., homologs, isomers). The analyte components are shown as a percent of the total concentration. As discussed in Section

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5.1, patterns displayed in these charts must be interpreted with caution. The changes in chemical composition and apparent trends shown by the bar charts may be indicative of unique patterns (e.g., distinctive source contributions), or they may be within the anticipated range of data variability. Further detailed forensic analyses outside the scope of this RI/FS are required to determine statistically significant variations among the data and contributions from various potential sources.

Other graphic displays used to assist with data interpretation include two scatter plots (Figures 5.23-3 and 5.23-8) with regression lines to fit the data and accompanying regression equations. Natural log-transformed PCB congener concentrations are regressed on natural log-transformed Aroclor concentrations in Figure 5.23-8 to display the relationship between PCB results obtained using different analytical methods. At EPA's request, Figures 5.2-11, 5.2-12, and 5.2-13 were generated to facilitate a discussion of the relationships among PCB homolog concentrations and deposition rates. The relationship between sediment accumulation rates and the percentage of fines (i.e., silt and clay, particles  $\leq 62 \mu\text{m}$ ) is shown in a scatter plot of the untransformed data sets (Figure 5.23-3). Plots of sample grain size distribution are shown in Figure 5.32-4. A line graph (Figure 5.32-1) is used to display the Willamette River daily discharge hydrograph for the entire sediment trap sampling period, with quarterly sampling periods identified by different colors. This hydrograph also displays average historical daily discharges for a 36-year period (1972–2008). Figure 5.32-5 shows the quarterly distribution of the daily Willamette River discharge combined with sediment accumulation rates (also depicted in Figure 5.32-2), and percent fines (also depicted in Appendix D2.1, Figure D2.1-22).

### 5.3.1 Overview of Sample Collection Effort

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The Round 3A in-river sediment trap sampling consisted of four rounds of sample collection over the course of a year's deployment in the LWR. A detailed description of field efforts associated with sediment trap deployment and recovery is included in the sediment trap data report (Anchor and Integral 2008) and in the respective FSRs for the initial deployment and each collection quarter (Anchor 2006d; 2007a,b,c; 2008c).

Sediment traps were deployed at 16 locations in the LWR from late 2006 through late 2007 (see Map 2.2-3). Twelve of the locations were within the Study Area between RM 1.9 and 11.5. One sediment trap was deployed just downstream of the Study Area at RM 1.8, two were located just upstream of Ross Island at RM 15.6 and 15.7, and one was located in Multnomah Channel. Paired sediment traps were deployed and maintained on opposite sides of the river at approximately RM 1.9, 6, 11.5, and 15.7. A total of 52 sediment trap samples were collected and analyzed per the protocols used in Rounds 2A and 2B. Sediment traps were deployed, sampled, and retrieved during the following periods:

Event	Date
Initial deployment of sediment traps	October 30 to November 2, 2006

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Quarter 1 (Winter) sample collection	January 30 to February 2, 2007
Quarter 2 (Spring) sample collection	April 30 to May 2, 2007
Quarter 3 (Summer) sample collection	August 8, 16, and 17, 2007
Quarter 4 (Fall) sample collection and final retrieval of sediment traps	November 13 and 14, 2007

Table 5.2-5 lists river miles, water depths, and location coordinates for each station. Sampling dates and sample recovery information for each deployment are shown in Table 5.2-6.

In total, 52 field samples were collected. Several factors precluded the collection and analysis of all 64 field sample attempts (16 locations x 4 quarters) plus accompanying QC samples as described in the FSP (Anchor 2006c). Traps were lost at three stations during the initial deployment period (Quarter 1) and at one location during Quarter 2. In addition, eight trap retrievals during Quarter 2 and Quarter 3 had sediment accumulation too low to warrant collection. Among the samples collected, an analytical prioritization scheme was used to determine the parameter schedule for samples with limited mass. PCB congener analysis had the highest priority and grain size analysis had the lowest priority. A detailed discussion of the decision rules for analytical priorities is included in the data report (Anchor and Integral 2008).

### 5.3.1.345.3.2 Sample Collection Methods and River Conditions During Sampling Events

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Sediment traps were deployed and maintained on both sides of the river at approximately RM 1.9, 6, 11.5, and 15.7. Individual sediment traps were deployed and maintained at seven other locations throughout the Study Area and at one location in Multnomah Channel. The number and locations of sediment traps and the frequency of recovery and redeployment were designed to capture anticipated spatial and temporal variability of suspended sediment mass and to investigate the potential accumulation of suspended sediment chemical constituents in suspected depositional areas. Sediment traps were initially deployed October 30 to November 2, 2006. Thereafter, sediment traps were recovered, sampled, and redeployed on a quarterly schedule until final recovery and sampling on November 13 and 14, 2007.

Hydrologic data used to assess flow patterns during sampling were obtained from the USGS stream flow station located upstream of the Morrison Bridge (Willamette River at Portland, gage no. 14211720). The stream flows measured during the sampling events are presented in Figures 5.3-1a and b. The highest flows during sampling occurred during Quarter 4+ of the 2009 sampling event, with a median daily discharge of 79164,000 cfs (Figure 5.32-1b). This period was characterized by variable flows, reaching twice the historical average discharge on a number of separate events. Much lower than normal discharge periods (≤Sup to 60 percent of average) occurred twice during the month of December 2009, only to be followed by higher than normal flows (up to 50 percent of average) in early January 2010. Higher than normal flows (up to 50 percent of average) also occurred twice during Quarter 1 of the 2006/2007 sampling event, the latter depression stretching into Quarter 2 of the 2006/2007 sampling event.

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The discharge record for Quarters 2 and 3 of the 2006/2007 sampling event (median discharges of 31,000 cfs and 10,000 cfs, respectively) did not demonstrate the variability that characterized Quarter 1 of the 2006/2007 sampling event. In general, sampling during Quarters 2 and 3, and at least a portion of Quarter 4 of the 2006/2007 sampling event and Quarter 3 of the 2009 sampling event (median discharge of 11,000 cfs), occurred during river flows that were very similar to historical averages. Discharge data from the last half of Quarter 4 of the 2006/2007 sampling event (October 2007 through mid-November 2007) are considered estimates due to uncertainty about the accuracy of the rating curve used at the Portland location for flows less than 20,000 cfs.

#### **5.3.1.35.3.3 Rates of Sediment Accumulation**

Net sediment accumulation rates at each station/quarter were calculated from the height of the sediment column in the traps and from the specific gravity and moisture content of the material. Sediment accumulation rates for each sediment trap are shown in Figures 5.3-2a and b. The highest rates of accumulation occurred during Quarter 1 of the 2006/2007 sampling event, with the largest accumulation in the sediment traps placed at RM 11.3 and 15.6 (Figure 5.23-2a and b); sediment accumulation rates were lower in the sediment traps placed downstream of RM 11.3. Since density measurements were only taken during the 2006/2007 sampling event, only that data was used to determine an average density of 1.22 g/cm<sup>3</sup> to calculate accumulation rates for the 2009 sampling event (Figure 5.3-2b). As mentioned previously, traps were lost at stations ST014 (RM 7.5), ST006 (Swan Island Lagoon), and ST016 (RM 9.9) during Quarter 1 of the 2006/2007 sampling event, so information regarding sediment accumulation is not available for these samples.

Medium-coarse silt made up approximately 50 percent of the trapped material during each quarter of the 2006/2007 sampling event, although the highest sediment accumulation rates generally corresponded with a comparatively low percentage of fine material in the sediment traps. Grain size data are only available for one sediment trap sample (ST001) in Quarter 3 of the 2009 sampling event and six sediment traps (ST001 through ST006) in Quarter 4. Figure 5.23-3 shows rates of accumulation as a function of percent fines. Trend lines shown for the data set as a whole ( $R^2 = 0.3844$ ), as well as for the individual quarters ( $R^2$  ranging from 0.0063 to 0.7946), suggest inverse linear relationships between accumulation rates and percent fines for this data set are weak. TOC showed relatively small differences among samples, with concentrations ranging from 1.1 to 3.5 percent. The majority approximately 75 percent of the measured TOC values, approximately 75 percent, range between 2 and 3 percent (Appendix D2.1, Figure D2.1-23).

Because sediment trap samples do not constitute temporally discrete samples (i.e., they represent a continuous collection over a three-month period), river conditions during sampling can only be discussed meaningfully in seasonal terms. Accumulation rates of

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trapped sediment may have been substantially affected by instantaneous events, such as high water resulting from heavy rainfall, but the impact of these isolated events cannot be quantified based on the existing data or the sampling methodology employed. Further, there were instances in which sediment traps were found to contain insufficient accumulated material for analysis were redeployed with the previous quarter's deposited material. In two cases (ST001 Quarter 3, and ST013 Quarter 3), traps retrieved in the following quarter were found to have a shorter column of sediment in them than they had when they were initially deployed (Table 5.32-16). In the case of ST013, a quarterly deposition rate of zero was used in Quarter 3 data presentations.

Figures 5.32-4a and b displays the grain size distributions for all sediment trap samples analyzed. As shown, samples from each station generally showed similar grain size distributions, except for an increase in the coarse-grained fraction (i.e., sand) during the winter quarter (Quarter 1) at stations ST008, ST009, and ST010, and during the fall quarter (Quarter 4) at ST007 during the 2006/2007 sampling event. Trends cannot be established for the trap data collected during the 2009 sampling event due to the lack of information in Quarter 3. The higher rate of sediment accumulation and the entrainment of sandy material in the sediment traps placed between RM 11.5 and 15.7 during Quarter 1 of the 2006/2007 sampling event and Quarter 4 of the 2009 sampling event may be due in part to the frequency of higher flow events that occurred during this period (Figures 5.32-5a and b). The distribution of flows shows that the maximum highest daily flows during 2006/2007 Quarter 2 and 2009 Quarter 4 were approximately the same as median 2006/2007 Quarter 1 flows, and a Approximately 75 percent of the 2006/2007 Quarter 1 daily discharge levels were higher than any of those recorded during 2006/2007 Quarters 3 and 4 and 2009 Quarter 3. A lower accumulation of trapped sediments, particularly at upriver stations, occurred during 2006/2007 Quarters 3 and 4 and 2009 Quarter 3 when comparatively low-flow events were typical.

#### 5.3.25.3.4 Total PCBs in Sediment Traps Mobile Sediment (Congeners and Aroclors)

##### 5.3.4.1 Total PCB Data Set

PCB congener analysis was conducted for all 6552 sediment trap samples; 6048 of these samples were also analyzed for PCB Aroclors (Tables 5.3-2 through 7). PCB congeners were detected in all 52 samples, with total PCB congener concentrations ranging from 0.9253-14 J µg/kg to 11,100 J µg/kg (Figures 5.23-6a and b). PCB Aroclors were detected in 4130 of the 6048 samples analyzed, with total Aroclor concentrations ranging from 3.1 U7.1J µg/kg to 2,600 µg/kg (Figure 5.2-7a and b).

The relationship between total PCB congener and total PCB Aroclor concentrations is shown in Figure 5.32-8 and discussed in detail in Appendix D1.5. The sediment trap correlation between paired congener and Aroclor totals is  $r^2=0.7$ . Although the PCB concentrations in sediment trap samples correlated well for the two methods, concentrations of total PCBs measured as congeners were higher overall than total PCBs measured as Aroclors. The methods used for analysis of PCB congeners and

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Aroclors are fundamentally different and would be expected to yield moderate differences in total PCB concentrations, as described in Appendix D1.5. In addition, among detected Aroclor results for the sediment trap samples about one third, ~~almost half~~ of the individual concentrations (1924 of 6050 results) were below the method reporting limit (MRL).

~~—Total PCB Spatial and Temporal Evaluation in Study Area~~  
~~There is less confidence that these estimated Aroclor concentrations are as accurate and precise as concentrations above the MRL. Ten additional Aroclor results were reported at concentrations less than two times the MRL. These values are also expected to be less precise than concentrations that are farther above the noise level of the system and well within the calibration range.~~

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5.3.4.2 The accuracy and precision of Aroclor data are also affected by PCB “weathering.” An examination of the Aroclor chromatograms indicates that many of the Aroclor patterns in the sediment trap samples were weathered, and that the PCB patterns in the samples did not match the Aroclor standards well. This affects the laboratory’s ability to identify, as well as quantify, the Aroclor(s) in the sample and is an inherent limitation to the Aroclor method. Because of the uncertainties in the Aroclor data related to concentrations near or below the MRL and to “weathering,” the following summary of PCB patterns and trends in sediment trap samples gives preference to PCB congener data.

The PCB concentrations varied by three orders of magnitude throughout the site. PCB congener concentrations were generally the highest higher in sediment traps located between in the vicinity of RM 6.7 and 11.3E (ST007 measured in 2006/2007 and ST003 measured in 2009) compared to other locations (Figures 5.3-6a and b). The greatest sample concentration (11,100 ug/kg) was measured in the fourth quarter of 2007. PCB concentrations at Station ST007 during low- and medium-flow periods (Quarters 2, 3 and 4) were elevated two to three orders of magnitude above concentrations at other locations for the respective periods. Other significant peaks are noted in 2009 at ST001 and ST002 just downstream of ST003, and in 2007 offshore of Fireboat Cove (ST015; RM 9.7W), at the head of in Swan Island Lagoon (ST006), and in Willamette Cove (ST013; RM 6.7E). PCB Aroclors show the same notable peaks at ST013, ST006, and ST007 (2006/2007 data set) and ST003 (2009 data set) as shown in Figures 5.3-7a and b. PCB concentrations upstream of RM 11.3 did not exceed 24 ug/kg for total Aroclors or 13 ug/kg for total congeners.

During the 2006/2007 sampling event, increasing concentrations generally occurred with each successive period at locations downstream of ST007 (RM 11.3E) at all stations except ST002 (RM 1.8W) and ST011 (RM 3.5 E), a trend that was clear in the PCB congener data but not apparent for Aroclors. The lack of an apparent trend with Aroclors is possibly due to higher detection limits for Aroclors resulting in a the lower

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number of samples with detectable Aroclor concentrations. The 2009 data set shows the same pattern where Quarter 3 of this data set corresponds to Quarter 4 of the 2006/7 data set and Quarter 3 corresponds to Quarter 1 of the 2006/7 data set. PCB concentrations at Station ST007 during low and medium flow periods (Quarters 2, 3 and 4) were elevated two to three orders of magnitude above concentrations at other locations for the respective periods. ST007 PCB congener concentrations during the highest flow period (Quarter 1) were much lower than during subsequent quarters, and only slightly above concentrations at downstream locations during the same period. Aroclors concentrations at ST007 were similarly elevated relative to other locations during Quarters 3 and 4, but unlike congeners, the total Aroclor concentration during Quarter 2 was one half the Quarter 1 concentration.

Figures 5.3-7a shows that concentrations in sediment traps are generally greater on the eastern shore of the river than the western shore. Concentrations also are greatest in sediment traps deployed at the upper end of the study area and show an apparent decreasing pattern in the downstream direction. There are two major exceptions to this observation at the upper end of the study area. The first is the sequence of sediment traps in the eastern nearshore area from RMs 11.3, 9.9, and 6.7 (ST007, ST006, and ST013) where the concentrations go from extremely high, to extremely low and then peak again before gradually decreasing through the study area. Conversely, the sequence of sediment traps in the western nearshore area from RMs 11.5, 9.7, and 7.5 (ST008, ST015, and ST014) show that the concentration go from extremely low, to extremely high, and then show a decreasing pattern through the study area. Both Aroclors and PCB congeners show these patterns.

The 2009 data is limited to the eastern nearshore area from RM 11.1 to 12.2. These sediment traps show that concentrations are generally the same in the upper river traps (ST007, ST006 and ST005) and then increase in trap ST004 before spiking in trap ST003 and then decreasing in ST002 and ST001. This pattern seems to show that there is some source of contamination between ST004 and ST003 that is influencing the concentration of the mobile sediments in those traps and the traps immediately downstream (ST002 and ST001). Both Aroclors and PCB congeners show this pattern.

It is also observed that the lowest concentrations were observed during the higher river flows (Figure 5.3-1a and b and 5.3-5) in Quarters 1 and 2; however, this period had the most accumulation in the traps (Figure 5.3-2a) suggesting that cleaner material deposits during river higher flows. During the summer period (Quarter 3), the river flows and sediment accumulation are the lowest, but the concentrations were the second highest. This observation suggests that there is a more localized influence on the material being deposited and may be due to bedload transport. The highest concentrations occurred when the river flows transitioned from low flow and were beginning to increase due to increasing storm events (late summer into fall). However, the accumulation in the traps during this time period is still quite low indicating that this is the period when the most of the more contaminated sediment in the site mobilizes.

#### 5.3.4.3 Total PCB Relationship by River Reach

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Aside from large differences in PCB levels between ST007 (RM 11.3E) and its paired location ST008 (RM 11.5W), there was little relative difference in PCB concentrations between other cross river sample pairs. Total PCB congener concentrations in the Study Area samples were all higher than the average PCB concentrations from upstream locations (ST009 and ST010)—one-to-five fold greater than upstream concentrations, in most cases. These trends were generally also reflected in the Aroclor data. The downstream total PCB concentrations (ST001 and ST002) are generally the same as the concentrations observed in Multnomah Channel (ST003) and seem to be approaching upriver concentrations, although the total PCB congener concentrations are about two fold higher. The concentrations entering the site, at least in the eastern nearshore region (ST005, ST006 and ST007 of the 2009 data set) are similar in concentration to the upriver sediment traps (ST009 and ST010) indicating that for the time periods measured, the downtown reach has little to no influence on the incoming depositional sediment concentrations.

The distribution of detected PCB homologs and Aroclors is shown in Figures 5.2-9 and 5.2-10, respectively. TetraCBs, pentaCBs, hexaCBs, and heptaCBs were the predominant homolog groups in the sediment trap samples. Aroclors 1254 and 1260 accounted for most of the reported Aroclors, which is consistent with the homolog composition. Aroclor 1254 consists primarily of pentaCBs followed by tetraCBs and hexaCBs, and Aroclor 1260 contains mostly hexaCBs and heptaCBs (Figure 5.1-34). DiCBs and triCBs were detected in most samples and are consistent with patterns displayed by weathered Aroclors 1254 and 1260.

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In addition to 1254 and 1260, Aroclors 1221 and 1242 were reported in eight instances. Aroclor 1221 was reported once, in the Quarter 3 sample from ST011 (RM 3.5E) at a concentration just above the method detection limit (MDL) and with qualifiers “NJ” (i.e., tentatively identified and estimated). Aroclor 1242 was identified in seven samples from Quarter 2, all at concentrations below the MRL of approximately 10 µg/kg, but was not identified during other sampling periods. Considering the low levels at which these Aroclors were detected and the regular occurrence of weathered Aroclor components among samples, it is conceivable that the partially dechlorinated PCBs in these samples led to misidentifications as Aroclors 1221 and 1242.

The higher concentrations and apparent increased dominance by hexaCBs and heptaCBs in samples from ST007 during Quarters 2, 3, and 4 in Figure 5.2-9 suggested that the dominance of higher chlorinated PCBs may increase with increasing concentrations. At EPA's request, the data were further analyzed to examine this possibility. A covariance matrix<sup>†</sup> of the sediment trap data set was constructed and investigated, both graphically and quantitatively. The data were log transformed,

<sup>†</sup> A regression analysis was not selected because homolog concentrations and total PCB concentrations are not independent variables, i.e., both are calculated from the same congener data set.

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centered and scaled to conform to the assumptions of normality and equal variance required for the parametric correlation metric used (Pearson's R).

The congener results showed a very uniform correlation structure, indicating that the relative homolog ratios were statistically similar among all samples regardless of total concentration. All of the PCB homologs had strong (Pearson's R in the 0.9 range) and significant positive relationships throughout the entire data set (Figure 5.2-11). Only decaCBs (otherwise a minor contributor to the total PCB concentration in all samples; Figure 5.2-9) had slightly lower correlations (Pearson's R in the 0.6 range) to the other nine homologs. Taken together, these results strongly suggest that across the entire range of total PCB concentrations within this data set, the relative proportions of all 10 PCB homolog groups are essentially constant.

Four homolog groups (tetraCBs, pentaCBs, hexaCBs, and heptaCBs) clearly dominate the PCB composition of all sediment trap samples (Figure 5.2-9), constituting 80 to 90 percent of total PCBs throughout the data set. Though the three samples (from Quarters 2, 3, and 4) collected at station ST007 visually appear to have slightly more hexaCBs and heptaCBs than others, quantitative analysis of these data indicates that the overall composition of these ST007 samples falls in line with the rest of the data set (Figures 5.2-11 and 5.2-12).

Also at EPA's request, the relationship between PCB homolog concentrations and the calculated net deposition rate of the sediment trap samples was examined (the deposition rate data variable is coded "DEPRT" in Figure 5.2-11). None of the PCB homologs, or total PCB concentrations, was significantly correlated to the solids deposition rates in the sediment traps (Figures 5.2-11 and 5.2-13).

PCB homolog distributions in sediment trap samples were generally consistent from quarter to quarter at each location resulting in a high degree of similarity among the samples in this data set. The PCB composition of all samples was dominated by tetraCBs, pentaCBs, hexaCBs, and heptaCBs (80-90 percent of total), but minor localized or temporal variations were also noticeable. These small-scale deviations may be indicative of potential localized sources, but also may be within the range of normal data variability. Detailed forensic analyses would be required to determine whether or not these minor variations represent statistically significant departures from the overall PCB pattern, which may be linked to local sources. Variations apparent in the stacked bar charts and a comparison of the paired sediment trap samples are discussed below:

- The Quarter 1 sample at ST009 (RM 15.7E) had a slight increase in the proportion of pentaCBs and hexaCBs, along with consistent contributions from tetraCBs and octachlorinated biphenyls (octaCBs). Samples at this station from the other three quarters had slightly greater contributions from diCBs, triCBs, tetraCBs, and octaCBs. ST010 (RM 15.6W) is located west of ST009, and the Quarter 1 sample from this station showed a slightly greater proportion of

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pentaCBs compared to other quarters, but to a lesser degree than was seen at ST009.

- HexaCBs and heptaCBs appeared to contribute increased proportions to the PCB concentrations at ST007 (RM 11.3E) as total concentrations increased in Quarters 2, 3, and 4. The proportion of octaCBs was also slightly higher in these samples, and the proportion of tetraCBs and pentaCBs was slightly lower, in comparison to those from upstream locations. This small scale change in PCB pattern, combined with the high concentrations, may indicate the presence of a localized source of PCBs in this vicinity during Quarters 2, 3, and 4.<sup>2</sup> The PCBs in Quarter 1 at this location were different from the subsequent quarters, with relatively higher percentages of triCB and tetraCB fractions, relatively lower hexaCB, octaCB and heptaCB fractions, and a much lower total PCB concentration. However, the overall composition profile and magnitude of total PCB concentration at ST007 are, in fact, closer to the other samples in this data set.
- The PCB patterns at ST008 (RM 11.5W), across from ST007, appeared slightly different from ST007, and the PCB concentrations were lower; ST008 does not appear to exhibit significant influence from ST007 in terms of PCB composition.
- A small shift of the pattern of higher chlorinated PCBs was consistently seen at ST006 (Swan Island Lagoon), ST015 (RM 9.7W), and ST016 (RM 9.9E). All samples from these stations were predominated by pentaCBs, hexaCBs, and heptaCBs.
- ST013 (RM 6.7E) in Willamette Cove was composed primarily of moderately chlorinated homologs (tetra through heptaCBs), with relatively high contributions from octaCBs in all three quarters sampled. While the PCB homolog distribution was consistent for all samples from this location, the total PCB congener concentration in the Quarter 4 sample was five times higher than during Quarter 1.
- The pattern of the Quarter 1 sample at ST004 (RM 6.0E) appeared slightly shifted towards higher contributions of hexaCBs and heptaCBs, whereas samples from other quarters at this station more closely matched the tetraCB, pentaCB, hexaCB, and heptaCB distribution of the other stations. ST005 (RM 6.0W), opposite ST004, had a relatively higher proportion of tetraCBs and pentaCBs, and lower abundance of heptaCBs compared to ST004. TriCBs made up a larger proportion of the samples from ST011 in Quarters 1 and 2 in comparison to other locations. The octaCB proportion appeared elevated in the Quarter 4 sample from this station. Quarter 3 and 4 samples from ST011 had

<sup>2</sup> Station ST007 is located between two facilities with active, deep draft docks (i.e., between RM 11.3E and 11.4E).

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total PCB congener concentrations two to three times higher than the Quarter 1 and 2 samples.

### 5.3.5 Total PCDD/Fs and TCDD TEQs in Sediment Traps Mobile Sediment

#### 5.3.5.1 Total PCDD/Fs and TCDD TEQs Data Set

~~5.3.15~~ Total PCDD/Fs and TCDD TEQ analysis was conducted for 60 sediment trap samples (Tables 5.3-2 through 7).

At least one dioxin (PCDD) or furan (PCDF) homolog constituent was detected in each of the 48 samples analyzed (Figure 5.2-14). Total PCDD/F homolog concentrations ranged from 5.16 J to 6,100 J pg/g. Total PCDD/F were detected in all 60 samples, with total PCDD/F concentrations ranging from 5.16 J pg/g to 6,100 pg/g (Figures 5.3-9a and b). TCDD TEQs were also detected in all 60 samples analyzed, with concentrations ranging from 0.0529 J pg/g to 16.3 J pg/g (Figure 5.2-10a and b).

#### 5.3.5.2 Total PCDD/Fs Spatial and Temporal Evaluation in Study Area

There was no apparent spatial gradient or trend in total PCDD/F concentrations. The highest total PCDD/F homolog concentration (6,100 J pg/g) occurred during Quarter 4 of the 2006/7 sampling event at ST006 (head of Swan Island Lagoon) (Figures 5.3-9a and b). This sample, and was elevated 1 to 2 orders of magnitude above concentrations at most other locations. However, the incidence of elevated a temporal evaluation of PCDD/Fs at ST006 other than during Quarter 4 could not be assessed since no samples from previous quarters were analyzed for total PCDD/Fs at this location. Additional total PCDD/F spikes-peaks of 1,820 J pg/g and 1,250 J pg/g occurred during Quarter 3 of the 2006/7 sampling event at ST007 (RM 11.3E) and at ST002 (RM 1.8W), respectively, representing the next highest levels found. Relatively high concentrations were also seen in Quarter 4 samples of the 2006/7 sampling event from in traps ST014 (RM 7.5W; 1,060 J pg/g) and ST007 (745 J pg/g), and and Quarter 1 samples from of the 2006/7 sampling event in traps ST001 (RM 1.9E; 563 pg/g) and ST011 (RM 3.5E; 535 pg/g).

Total PCDD/F concentrations were greatest in Quarter 3 of the 2009 data set with the highest concentration (1,640 pg/g) in sediment trap ST001 at RM 11.1 followed by traps ST004 (RM 11.6; 1,280 pg/g), ST003 (RM 11.4; 1,120 pg/g), and ST006 (RM 11.9; 900 pg/g). Relatively high concentrations were also seen in Quarter 4 of the 2009 sampling event in trap ST005 (RM 11.8; 879 J pg/g). The temporal pattern in the 2009 data set indicates that Quarter 3 concentrations are greater than Quarter 4 concentrations, which would mean that the concentration at ST005 during this period may have had the greatest sample concentration in this area.

Samples collected in the 2006/2007 sampling event with total PCDD/F concentrations greater than 500 pg/g are observed in ST001 (RM 1.9E) and ST011 (RM 3.5E) during



Quarter 1; ST002 (RM 1.8W) and ST007 (RM 11.3E) during Quarter 3; and ST014 (RM 7.5W), ST006 (Swan Island Lagoon), and ST007 (RM 11.3E) during Quarter 4.

There is no apparent spatial gradient or trend in total PCDD/F concentrations throughout the river indicating that concentrations measured in sediment traps are more representative of localized sediments. The highest PCDD/F concentrations among stations generally occurred during Quarters 4 and 3. Stations ST007 and ST009 in the eastern nearshore zone contained higher total PCDD/Fs than ST008 and ST010 placed in similar river miles in the western nearshore zone during these periods. This information indicates that settleable solids in the traps have an affinity to localized sediments rather than being representative of broader mobile sediments in the river system.

#### **5.3.5.3 TCDD TEQ Spatial and Temporal Evaluation in Study Area**

The highest TCDD TEQ was found in the Quarter 4 sample of the 2006/7 sampling event in trap ST006 (Swan Island Lagoon) (Figure 5.2-10a and b). Like total PCDD/Fs, Quarter 4 was the only time TCDD TEQ were analyzed at this location so it is difficult to gauge the occurrence of similar TCDD TEQ concentrations during other periods or the potential that there is a localized source. TCDD TEQs greater than 1 pg/g were measured during the 2006/7 sampling event at ST001 (RM 1.9E), ST011 (RM 3.5E), and ST005 (RM 6.0W) during Quarter 1; ST002 (RM 6.0W) during Quarter 2; ST002 (RM 1.8W) and ST007 (RM 11.3E) during Quarter 3; and ST014 (RM 7.5W), ST006 (Swan Island Lagoon), ST007 (11.3E). During Quarter 3 of the 2009 sampling event, TCDD TEQ values greater than 1 pg/g occurred in all sediment traps except ST002 and were not analyzed in ST005. TCDD TEQ values greater than 1 were also present in Quarter 4 of the 2009 sampling event in traps ST004 and ST0005. TCDD TEQ spatial and temporal patterns were similar to total PCDD/F patterns.

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#### **5.3.5.4 Total PCDD/F and TCDD TEQ Relationship by River Reach**

Study Area locations generally had total PCDD/F and TCDD TEQ concentrations higher than ~~average~~ concentrations from the upstream locations. However, total PCDD/F and TCDD TEQ concentrations from the two upstream locations were not similar to each other, with concentrations from ST009 (RM 15.7E) averaging more than six times those from ST010 (RM 15.6W). Some ST009 samples had comparatively higher total PCDD/F and TCDD TEQ concentrations than concurrently sampled Study Area locations during the same quarters (Figures 5.3-9a and 5.3-10a-and-b).

Total PCDD/F and TCDD TEQ concentrations in the downstream reach were elevated above the upriver sediment traps (ST009 and ST010) at ST001 (RM 1.9E), ST002 (RM

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1.8W). Total PCDD/Fs and TCDD TEQ in the study area reach were also elevated above the upriver traps at traps ST011 (RM 3.5E), ST014 (RM 7.5W), ST006 (Swan Island Lagoon), and ST007 (RM 11.3E). Total PCDD/Fs in the study area were also elevated above the upriver traps at ST005 (RM 6.0W).

Total PCDD/F concentrations downstream of the study area were greater in Multnomah Channel (ST003) during Quarter 4 of the 2006/7 sampling event than in the lower study area (RM 3.5 to 7.5). TCDD TEQ concentrations were also elevated in this sample. Mobile sediments were also greater downstream at ST002 (RM 1.8W) during Quarter 3 of the 2006/7 sampling event than anywhere else below RM 11.3E (ST007) in the main channel and at ST001 (RM 1.9E) during Quarter 1 of the 2006/2007 sampling event than anywhere in the main channel of the study area.

The highest PCDD/F concentrations among stations generally occurred during Quarters 4 and 3. Stations ST007 and ST009 contained higher total PCDD/Fs than their counterparts during these periods. However, the east (ST004) and west (ST005) pair at RM 6 had nearly identical concentrations during all quarters analyzed.

Homolog patterns for sediment trap samples showed OCDD as the dominant homolog in almost all sediment trap samples, with HpCDDs present to a substantial degree in most samples (Figure 5.2-15). PCDFs generally accounted for less than about 20 percent of the total PCDD/Fs in most of the samples. OCDF typically accounted for the highest furan concentrations, followed by HpCDFs.

Samples with homolog patterns apparently different from the prevailing pattern were observed at several locations, but these patterns are obscured because U-qualifiers were applied during data validation in most cases; non-detects are treated as zero in the graphs of chemical patterns. However, the Quarter 2 sample from ST008 (RM 11.5W) was notable for its relatively high proportions of OCDF and relatively low proportions of OCDD compared to other samples.

The following samples have incomplete PCDD/F patterns because some of the PCDD/F homolog data were qualified as undetected during validation (Anchor and Integral 2008): ST010, Quarter 2 (HpCDDs undetected) and Quarter 4 (HpCDFs and OCDF undetected); ST003 (Multnomah Channel), Quarter 2 (HxCDDs, HxCDFs, HpCDDs, HpCDFs, and OCDD undetected); ST008, Quarter 4 (HpCDFs and OCDF undetected); and ST016 (RM 9.9E), Quarter 4 (HpCDFs undetected).

Samples with total PCDD/F concentrations >500 pg/g—ST001 and ST011 from Quarter 1; ST002 and ST007 from Quarter 3; and ST014, ST006, and ST007 from Quarter 4—had apparently similar homolog patterns.

#### **5.3.15.1 TCDD TEQs in Sediment Traps**~~Mobile Sediment~~

Measurable TCDD TEQs were found in all samples at concentrations ranging from 0.05 J pg/g to 16.3 J pg/g (Figure 5.2-16). The highest TCDD TEQ was found in the

Quarter 4 sample from ST006 (Swan Island Lagoon). Since Quarter 4 was the only time PCDD/Fs were analyzed at this location, it is difficult to gauge the occurrence of similar PCDD/F concentrations during other periods or the potential that there is a localized source. TEQs  $\geq 1$  pg/g were also found at ST007 (RM 11.3E) during Quarters 3 and 4; the Quarter 3 sample from ST002 (RM 1.8W); ST014 (RM 7.5W) during Quarter 4; and Quarter 1 samples from ST001 (RM 1.9E), ST011 (RM 3.5E), and ST005 (RM 6.0W), where the Quarter 2 sample was also  $>1$  pg/g.

TEQ concentrations derived from PCDD/Fs closely track total PCDD/F homolog concentrations, both geographically and seasonally. The close parallel is due to the resemblance in homolog patterns among samples. TEQ concentrations are generally two to three orders of magnitude lower than total PCDD/F homolog concentrations due to the abundance of higher chlorinated 2,3,7,8-substituted dioxins and furans, which have less toxic equivalency than tetra- and penta-chlorinated congeners.

### 5.3.6 Total DDx in Sediment Traps/Mobile Sediment

#### 5.3.6.1 Total DDx Data Set

Total DDx analysis was conducted for 63 sediment trap samples (Tables 5.3-2 through 7). DDx compounds were detected in all but ~~one-two~~ sediment trap samples (Figure 5.2-17). Concentrations of total DDx ranged from 0.6998  $\mu\text{g/kg}$  to 150  $\mu\text{g/kg}$  in samples with detectable concentrations.

#### 5.3.6.2 Total DDx Spatial and Temporal Evaluation in Study Area

The highest total DDx concentration (150  $\mu\text{g/kg}$ ) occurred during Quarter 4 of the 2006/7 sampling event at ST007 (RM 11.3E) and was an order of magnitude higher than ~~most other samples~~ the next highest sample. Peak total DDx concentrations greater than 10  $\mu\text{g/kg}$  are observed in sediment traps ST007 (RM 11.3E), ST006 (Swan Island Lagoon), ST011 (RM 3.5E), and ST014 (RM 7.5W) during Quarter 3 of the 2006/7 sampling event. During Quarter 4 of the 2006/7 sampling event, peak total DDx concentrations are observed in traps ST007 (RM 11.3E), ST006 (Swan Island Lagoon), ST004 (RM 6.0E), ST015 (RM 9.7W), ST014 (RM 7.5W), ST005 (RM 6.0W), and ST012 (RM 4.5W). Peak total DDx concentrations occurred in the 2009 sampling event in trap ST001 (RM 11.1) during the third quarter and trap ST003 (RM 11.4) during Quarters 3 and 4. Quarter 4 samples from ST005 (RM 6.0W) and ST006 (Swan Island Lagoon) had the second and third highest concentrations, 33  $\mu\text{g/kg}$  and 31  $\mu\text{g/kg}$ , respectively.

At most locations, total DDx concentrations were highest during Quarter 4 in both the 2006/7 and 2009 sampling events, although the time frame of the year composing these quarters differs (Figures 5.3-11a-b). The sediment traps placed in the eastern nearshore

zone show a pattern of high-low-high-low, indicating that there are at least two sources of DDx in the eastern shore of the study area. A prominent source is observed at RM 11.3 and a lesser source at RM 6, which may also be deposition sediments from the source at RM 11.3. A source is also observed in Swan Island Lagoon. In the western nearshore zone, the concentrations increase from the upper end of the study area (RM 11.5) to the midpoint at RM 6.0 and then decrease to the lower end of the study area. This indicates that there are a number of sources between RM 9.7 and 4.5 with a prominent source between RM 6.0 and 7.5.

~~Among locations, samples collected from sediment traps at RM 6 to 11.3 generally had the highest total DDx concentrations. Downstream of RM 6, total DDx concentrations appeared to be similar within quarters or to decrease slightly with distance downstream. The maximum concentration found downstream of RM 6 (15 J µg/kg) was low relative to maximum concentrations from stations located at RM 6 through 11.3.~~

~~Total DDx concentrations in Study Area samples were generally higher than those from upstream locations. Overall, 35 of the 43 (81 percent) Study Area samples had higher total DDx concentrations than average concentrations from concurrent upstream samples. Differences between Study Area and upstream samples were most pronounced during Quarters 3 and 4, when the combined average Study Area total DDx concentration was six fold that of the combined average concentrations from upstream locations. By contrast, Study Area samples from the first two quarters had a combined average total DDx concentration 34 percent higher than the combined average concentration of upstream samples.~~

~~Paired samples from opposite sides of the river at RM 1.8–1.9 (ST002/ST001) and at RM 15.6–15.7 (ST010/ST009) had similar total DDx concentrations, whereas high Quarter 4 total DDT levels were noted at ST005 and ST007 compared to their respective counterparts, ST004 (RM 6.0E) and ST008 (RM 11.5W; Figure 5.2-17).~~

~~The relative concentration of DDD, DDE, and DDT varied widely among samples. Among the 2,4' and 4,4' isomers, the 4,4' isomers generally predominated (Figure 5.2-18). On average, 4,4' DDT comprised the largest proportion of total DDx (29 percent of total), followed by 4,4' DDE (26 percent), and 4,4' DDD (21 percent). Among the 2,4' isomers, 2,4' DDT was found at the highest percentage of total DDx (12 percent on average), followed by 2,4' DDD (10 percent), and 2,4' DDE (one percent).~~

~~Stations ST007 and ST015 (RM 9.7E) had the highest proportion of 2,4' DDx compounds due to comparatively high percentages of 2,4' DDD and 2,4' DDT. Station ST013 (RM 6.7W) also had a high percentage (52 percent) of 2,4' DDT in the Quarter 4 sample. Upstream samples were primarily composed of 4,4' DDx isomers.~~

~~The DDD isomers exhibited variability in both their concentration and relative contributions at most stations; no seasonal or geographic trends were evident. DDT~~

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isomers appeared to have the highest relative concentrations during Quarter 1, although no geographical trends were apparent. A more seasonal trend was observed for DDE isomers, where they were reported at detectable concentrations in all but two of the samples from Quarters 2 through 4, yet were detected in only three of the 13 samples from Quarter 1. Relative contributions of DDE compounds to total DDx were generally highest during Quarter 4.

Patterns of relative concentrations of DDx constituents among samples are somewhat confounded by elevated detection limits and interferences. ~~Of the 300 DDx results,~~ ~~4~~ Detection limits were elevated in 18 percent ~~of the samples~~, and another four percent were classified as non-detects due to contamination in the associated laboratory or field blanks (Anchor and Integral 2008). The elevated detection limits could obscure low concentrations of DDx. ~~Because non-detected results are treated as zero in Figure 5.2-18, true patterns of relative concentration among the various isomers and congener compounds may also be obscured.~~ In addition, 9 percent of the results were qualified as tentatively identified and estimated (NJ) during data validation due to poor confirmation, and another 15 percent were estimated (J) as a result of the confirmation data.

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#### 5.3.6.3 Total DDx Relationship by River Reach

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Total DDx concentrations in Study Area samples were generally higher than those from upstream locations. Overall, 24 of the 63 (38 percent) Study Area samples had higher total DDx concentrations than the maximum concentration from upstream samples. Differences between Study Area and upstream samples were most pronounced during Quarters 3 and 4 of both the 2006/7 and 2009 sampling events. By contrast, Study Area samples from the first two quarters had total DDx concentrations that are only nominally higher than the concentrations observed in the upstream samples.

Concentrations of total DDx in the downstream reach at ST001 (RM 1.9E) were elevated above the upriver sediment traps (ST009 and ST010); however, ST002 (RM 1.8W) concentrations seemed consistent with the upriver concentrations. Total DDx in all the study area reach traps were also elevated above the upriver traps except traps ST016 (RM 9.9E) and ST013 (RM 6.7E).

Total DDx concentrations downstream of the study area were lower or about the same in Multnomah Channel (ST003) during the 2006/7 sampling event than in the study area. Mobile sediments were also lower downstream at ST002 (RM 1.8W) than at ST001 (RM 1.9E) or ST003 (Multnomah Channel).

**Total DDx at ST007 Quarter 3 and 4 samples (24 and 150 µg/kg, respectively) were composed entirely of 2,4'-DDD. However, 2,4'-DDD reported by the laboratory in these cases may be artifacts of PCB interference. High concentrations of Aroclor 1260 were also detected at**

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~~this station in these samples (1,800 and 2,600 µg/kg respectively). Aroclors have the potential to interfere with the analysis of DDx due to co-elution of Aroclor peaks with DDx compounds. While the 2,4'-DDD results were not N-qualified during data validation, the results for other isomers (2,4'-DDT and 4,4'-DDT in both Quarters 3 and 4, and 2,4'-DDE in Quarter 4) were N-qualified. It is possible that the reported results are affected by Aroclor interferences.~~

### 5.3.17.3.7 Total PAHs in Sediment Traps~~Mobile Sediment~~

#### 5.3.7.1 Total PAH Data Set

Total PAH analysis was conducted for 63 sediment trap samples (Tables 5.3-2 through 7). PAHs were detected in all samples analyzed, with concentrations of total PAHs ranging from 77 J µg/kg to 11,000 µg/kg ~~(Figure 5.2-19)~~.

#### 5.3.7.2 Total PAH Spatial and Temporal Evaluation in Study Area

The PAH concentrations varied by three orders of magnitude throughout the site. Total PAH concentrations were the highest in sediment traps located in the vicinity of RM 6.0W (ST005 measured in 2006/7) compared to other locations (Figures 5.3-12a and b). The greatest sample concentration (11,000 ug/kg) was measured in the fourth quarter of 2007. Other significant peaks (greater than 1,000 ug/kg) are noted in 2007 at ST006 (Swan Island Lagoon), ST014 (RM 7.5W), ST004 (RM 6.0E), ST011 (RM 3.7E), ST014 (RM 7.5W), ST012 (RM 4.5W), and in 2009 at ST001 and ST003 within RM 11E.

During the 2006/2007 sampling event, the highest PAH concentrations within stations tended to occur during Quarters 3 and 4, but additional seasonal differences among stations were not apparent. The lack of an apparent trend is possibly due to the lack of samples collected for every quarter at all stations. The 2009 data set also shows the lack of a trend where some samples are greater in Quarter 3 while others are greater in Quarter 4.

Figure 5.3-12a shows that concentrations in sediment traps are generally greater on the western shore of the river than the eastern shore. Concentrations also are greatest in sediment traps deployed at the middle of the study area and show an apparent decreasing pattern in the downstream direction.

The 2009 data is limited to the eastern nearshore area from RM 11.1 to 12.2. These sediment traps show that concentrations vary throughout the area. This pattern seems to show that there may be several sources of contamination that is influencing the concentration of the mobile sediments in this area.

It is also observed that the lowest concentrations were observed during the higher river flows (Figure 5.3-1a-b and 5.3-5) in Quarters 1 and 2 of the 2006/7 sampling event; however, this period had the most accumulation in the traps (Figure 5.3-2a) suggesting that cleaner material deposits during river higher flows. During the summer period

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(Quarter 3), the river flows and sediment accumulation are the lowest, but the concentrations were the second highest. This observation suggests that there is a more localized influence on the material being deposited and may be due to bedload transport. The highest concentrations occurred when the river flows transitioned from low flow and were beginning to increase due to increasing storm events (late summer into fall). However, the accumulation in the traps during this time period is still quite low indicating that this is the period when the most of the more contaminated sediment in the site mobilizes.

#### 5.3.7.3 Total PAH Relationship by River Reach

Total PAH concentrations were greater upriver in ST010 (RM 15.6W) during Quarter 1 of the 2006/7 sampling event than all other samples, except ST005 (RM 6.0W). Samples in the upper reaches (RM 8 to 11.8) of the Study Area seem consistent with samples collected upriver, although the 2009 data indicate that there are high PAH levels in the vicinity of RM 11E.

The downstream total PAH concentrations (ST001 and ST002) seem to be approaching upriver concentrations, although the downstream total PAH concentrations are about two to four fold higher. Total PAH concentrations at ST005 (RM 6.0W) were elevated an order of magnitude above most other locations during Quarters 1, 2, and 4 (PAHs were not analyzed at ST005 during Quarter 3).

In general, total PAH concentrations were higher at locations between RM 3 and 6, including Multnomah Channel (ST003) which had a relatively high Quarter 4 level (2,700  $\mu\text{g/kg}$ ). Total PAH concentrations upstream of RM 9.7 were generally lower, with only two samples exceeding 500  $\mu\text{g/kg}$ : 640  $\mu\text{g/kg}$  at ST007 (RM 11.3E) during Quarter 3 and 1,300  $\mu\text{g/kg}$  at ST010 (RM 15.6W) during Quarter 1.

The highest PAH concentrations within stations tended to occur during Quarters 3 and 4, but additional seasonal differences among stations were not apparent.

#### Total PAH Relationship by River Reach

Most samples analyzed from Study Area locations had total PAH concentrations exceeding average upstream concentrations during concurrent sampling periods. Overall, 323 of the 3443 (94 percent) Study Area samples had total PAH concentrations higher than concurrent samples from upstream locations, with the exception of Quarter 1, where the average total PAH concentration of upstream samples ST010 (1,3700  $\mu\text{g/kg}$ ) was higher than most all but one Study Area sample (ST005)s. During subsequent quarters, however, concentrations upstream were lower (combined average of 190  $\mu\text{g/kg}$ ), and 91 percent of Study Area samples had total PAH concentrations an average of six times greater than those from upstream. Generally, concentrations in the Study area were less than ten times the upriver concentrations.

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with the exception of samples collected at ST005 (RM 6.0W) where concentrations were up to 40 times the upriver concentrations.

Samples in the upper reaches (RM 8 to 11.8) of the Study Area seem consistent with samples collected upriver, although the 2009 data indicate that there are high PAH levels in the vicinity of RM 11E. The 2009 data also show that there is large variability in localized areas of the site (Figure 5.3-12b) with concentrations ranging over an order of magnitude within the river mile. The downstream total PAH concentrations (ST001 and ST002) seem to be approaching upriver concentrations, although the downstream total PAH concentrations are about two to four fold higher. In general, total PAH concentrations were higher at locations between RM 3 and 6, including Multnomah Channel (ST003) which had a relatively high Quarter 4 level (2,300 J  $\mu\text{g/kg}$ ). Paired samples generally did not display substantial differences in total PAH concentrations, with two notable exceptions. There were large differences between total PAH concentrations at ST005 and its cross-river counterpart (ST004, RM 6.0E) during all quarters where samples from both stations were analyzed. Total PAH concentrations during Quarter 1 at ST010 were also higher than the concurrent sample from ST009 (RM 15.7E).

An evaluation of the PAH composition among samples was done by combining the 17 individual PAH compounds into categories determined by their number of fused rings, as described in Section 5.1.8.4. Fused ring patterns did not appear to vary substantially among samples, with four-ring PAHs as the predominant component, followed by those with five rings (Figure 5.2-20). HPAHs (PAHs with four or more fused rings) generally accounted for more than 80 percent of total PAHs. LPAHs (PAHs with two or three fused rings) accounted for a maximum of one-third total PAH concentrations, and exceeded 20 percent of total PAHs in only nine of 49 samples analyzed. A bar chart of all site PAHs (Figure 5.2-21) shows that the four-ring PAHs consist primarily of fluoranthene and pyrene and the five-ring PAHs consist primarily of BAP and benzo(b)fluoranthene. These four PAHs account for approximately 50 percent of the total PAHs in all samples.

The PAH distributions at ST005, the location with the highest total PAH concentrations, were similar to the prevailing pattern. Samples with PAH distributions that appeared to differ somewhat from the prevailing pattern were observed at several locations:

- The Quarter 2 sample from ST009 (RM 15.7E) exhibited apparent increased contributions from five-ring PAHs, mainly BAP.
- At ST002 (RM 1.8W) the Quarter 2 and 3 samples exhibited apparent increased contributions from five-ring and six-ring PAHs. However, the distribution of the individual PAHs within the five-ring and six-ring PAH groups appeared similar to other samples.
- At ST003 (Multnomah Channel), apparent increased contributions from five-ring and six-ring PAHs were observed in the Quarter 2 and 4 samples. The

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distribution of the individual PAHs within the five-ring and six-ring PAH groups appear similar to other samples.

The evaluation of the LPAH distributions is confounded by the fact that eight results for naphthalene (a two-ring PAH) from Quarter 2 were restated as undetected because of laboratory blank results (Anchor and Integral 2008). The levels of LPAHs in these Quarter 2 samples may be under-represented. With that caveat, samples from Quarter 1 at ST010 (RM 15.6W), Quarter 3 at ST011 (RM 3.5E), and Quarter 4 at ST003 (Multnomah Channel) all with total PAH concentrations greater than 1,000 µg/kg (1,300 J µg/kg, 1,600 J µg/kg, and 2,700 J µg/kg, respectively) are notable for their low contribution (less than 20 percent) of LPAHs to the total PAHs.

In cases where LPAHs constitute more than 20 percent of the total, naphthalene accounts for 60 to 85 percent of the two-ring PAHs. Phenanthrene accounts for over 50 percent of the three-ring PAHs, with anthracene accounting for an additional 10 to 30 percent of the three-ring PAHs. Samples with more than 20 percent LPAHs include: ST009, Quarters 1 and 3; ST010, Quarter 4; ST008 (RM 11.5W), Quarters 1 and 2; ST007, Quarter 3; ST015 (RM 9.7W), Quarter 3; ST013 (RM 6.7E), Quarter 1; and ST004, Quarters 1 and 2.

### 5.3.17—Additional Indicator Chemicals in Sediment Traps

#### 5.3.17.25.3.8 Bis(2-ethylhexyl)phthalate in Sediment Traps Mobile Sediment

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##### 5.3.8.1 BEHP Data Set

BEHP analysis was conducted for 56 sediment trap samples (Tables 5.3-2 through 7). BEHP was detected in all samples analyzed at concentrations ranging from 35 µg/kg to 1,600 µg/kg (Figure 5.2-22).

##### 5.3.8.2 BEHP Spatial and Temporal Evaluation in Study Area

BEHP concentrations varied by two orders of magnitude throughout the site. BEHP concentrations were greatest during Quarters 3 and 4 of the 2006/7 sampling event (1,600 µg/kg and 710 µg/kg) at ST006 (Swan Island Lagoon), although samples were not analyzed at ST006 during Quarters 1 and 2 (Figure 5.3-13a). Peak concentrations were also noted at ST007 (RM 11.3E) during Quarters 2, 3 and 4 and ST015 (RM 9.7W) during Quarter 4. were elevated an order of magnitude above most other locations, although BEHP at ST010 (RM 15.6W) approached the Quarter 4 level from ST006 (480 J µg/kg vs. 710 µg/kg). Concentrations downstream of Swan Island Lagoon throughout the site were generally less than 250 µg/kg, except as noted above, and -varied less within and among stations and sampling periods than did BEHP concentrations upstream of Swan Island Lagoon most during Quarter 4 of the 2006/7 sampling event with values ranging by a factor of 4 (excluding peak concentrations). There is no observable spatial or temporal trend in the concentrations of BEHP throughout the site.



BEHP concentrations upstream of Swan Island Lagoon were generally highest during Quarters 3 and 4, whereas the highest concentrations downstream of Swan Island Lagoon generally occurred during Quarters 1 and 2. Concentrations measured in the 2009 sampling event (Tables 5.3-6 and 7; Figure 5.3-13b) reveal that concentrations in localized areas of the site vary greatly. Concentrations in Quarter 3 varied by a factor of five, while concentrations in Quarter 4 varied by a factor of three. Peak concentrations (greater than 250 ug/kg) are noted in ST002, ST006, and ST007 during Quarter 3 and ST001, ST002, ST003, ST005, and ST006 during Quarter 4.

#### 5.3.8.3 BEHP Relationship by River Reach

Average upstream BEHP concentrations at ST009 (RM 15.7E) and ST010 (RM 15.6W) were generally lower than Study Area locations during concurrent sampling. During Quarter 4, however, the BEHP concentration at ST010 (480 J ug/kg) was higher than at all Study Area locations except ST006 (Figure 5.3-13a). Quarter 3 also showed higher upriver concentration in ST009 (210 ug/kg) than at ST004 (81 ug/kg) and ST012 (150 ug/kg).

Concentrations in the downstream traps (ST001 and ST002) and in Multnomah Channel (ST003) were lower than concurrent Study Area traps. In Quarters 1 and 2, the downstream traps show that mobile concentrations were at or approaching upriver concentrations. During Quarters 3 and 4, the downstream traps had lower concentrations than the upriver traps. BEHP concentrations in paired samples appeared closely matched at RM 6 and locations downstream. Upstream of RM 6, paired samples appeared less similar, with BEHP concentrations at ST007 (RM 11.3E) and ST010 (RM 15.6W) generally higher than their respective counterparts (ST008 and ST009).

### 5.3.17.35.3.9 Total Chlordanes in Sediment Traps Mobile Sediment

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#### 5.3.9.1 Total Chlordanes Data Set

One or more chlordanes were detected in approximately 70 percent of the 63 samples analyzed (Figure 5.2-23 Tables 5.3-2 through 7). Detectable concentrations of total chlordanes ranged from 0.22 J to 3.7 NJ ug/kg. Extremely high, although reporting limits for non-detects ranged from 0.63 to are noted in trap ST007 during Quarters 3 and 4 of the 2006/7 sampling event (98 and 460 ug/kg, respectively) and in trap ST003 during Quarter 4 of the 2009 sampling event (86 ug/kg). Detection limits were also notably high in traps ST001 and ST003 during Quarter 3 of the 2009 sampling event (3.2 and 4.3 ug/kg, respectively). These elevated NDs appear to be due to matrix interferences. These samples all had relatively high PCBs levels which likely interfered with the pesticide quantification.

### 5.3.9.2 Total Chlordanes Spatial and Temporal Evaluation in Study Area

The highest detected total chlordanes concentration was found at ST008 (RM 11.5W) during Quarter 1 (Figures 5.3-14a-b). Other comparatively high detected concentrations ( $>3 \mu\text{g/kg}$ ) were found during Quarter 4 at ST011 (RM 3.5E) and during Quarter 3 at ST006 (Swan Island Lagoon). Total chlordane concentrations were highly variable within and among locations and within and among seasons. Higher concentrations were noted in Quarters 1, 3 and 4 of the 2006/7 sampling event than in Quarter 2. Although west-side samples had higher levels during Quarter 1 than east-side sediment traps, variations in data were difficult to assess due to the number of non-detects and the vast range of reporting limits. Therefore, spatial and seasonal gradients or trends were not apparent.

### 5.3.9.3 Total Chlordanes Relationship by River Reach

Overall, Study Area total chlordane concentrations were higher than upstream concentrations. The maximum total chlordanes in ~~all~~ upstream samples was 1 ~~NJ~~  $\mu\text{g/kg}$ , whereas nine of the 14 Study Area stations had at least one sample with greater than 1  $\mu\text{g/kg}$  total chlordanes. Only one downstream sample in ST002 had a concentration greater than 1  $\mu\text{g/kg}$ . West-side samples from RM 6 (ST005) and 11.5 (ST008) had higher levels during Quarter 1 than their respective east-side sediment traps, ST004 and ST007, but similarities or differences between paired samples were difficult to assess due to the number of non-detects and the vast range of reporting limits.

## 5.3.17.45.3.10 Aldrin and Dieldrin in ~~Sediment Traps~~ Mobile Sediment

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### 5.3.10.1 Aldrin and Dieldrin Data Sets

Aldrin and dieldrin, two closely related organochlorine pesticides, were analyzed in 63 samples. Aldrin was detected in six samples and dieldrin was detected in five samples each (Figures 5.2-24 and 5.2-25 Tables 5.3-2 through 7). None of the samples analyzed contained detectable levels of both aldrin and dieldrin for the same sample. Extremely high reporting limits for non-detects are noted in trap ST008 during Quarter 1 of the 2006/7 sampling event for both aldrin and dieldrin (1.6 and 3  $\mu\text{g/kg}$ , respectively), traps ST004 and ST007 during Quarter 3 of the 2006/7 sampling event for dieldrin (1.1 and 13  $\mu\text{g/kg}$ ), and in trap ST006 during Quarter 4 of the 2006/7 sampling event (1.2  $\mu\text{g/kg}$ ). All other non-detected values were less than 1  $\mu\text{g/kg}$ .

~~All of the~~ The detected concentrations of aldrin ~~were at similar levels (ranged from 0.22 to 1.1  $\mu\text{g/kg}$  to 1.1  $\mu\text{g/kg}$  (Figures 5.3-15a-b)), with the highest concentration found at Station ST005 (RM 6W). Two of the detected aldrin samples were at downstream locations ST001 (RM 1.9E) and ST003 (Multnomah Channel).~~ Detected dieldrin concentrations were more variable (Figures 5.3-16a-b), with concentrations ranging from 0.15  $\mu\text{g/kg}$  ~~at ST003 (Multnomah Channel)~~ to a maximum of 4.9  $\mu\text{g/kg}$  at ST006 (Swan Island Lagoon). Two of the five dieldrin detections were at the upstream location ST009 (RM 15.7E) and one was downstream at ST003 (in Multnomah Channel).

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#### **5.3.10.2 Aldrin and Dieldrin Spatial and Temporal Evaluation in Study Area**

There were four detected values for aldrin within the Study Area.

Two of the five (80 percent) aldrin detections occurred during Quarter 1 of the 2006/7 sampling event at ST005 (6.0W) and ST012 (4.5 W), one detection occurred during Quarter 4 of the 2006/7 sampling event at ST014 (7.5W), and one detection occurred during Quarter 4 of the 2009 sampling event at ST002 (RM 11.3E).

There were two detectable dieldrin concentrations within the Study Area. Both were found-measured during Quarters 3 of the 2006/7 sampling event at ST006 (Swan Island Lagoon) and ST011 (RM 3.5E) and 4.

The infrequency of detections did not allow for assessment of a possible geographical concentration gradient or trend. Of the three instances where either aldrin or dieldrin was detected at a paired sample location, corresponding cross-river locations had no detectable concentration. However, All detected aldrin concentrations occurred primarily at or below RM 7.5 in the western nearshore zone, while dieldrin was detected in Multnomah Channel (ST003), RM 3.5E (ST011), Swan Island Lagoon (ST006), and upriver at RM 15.7E (ST009) primarily in the eastern nearshore zone.

#### **5.3.10.3 Aldrin and Dieldrin Relationship by River Reach**

Aldrin was not detected in upriver samples, but was detected in two downstream samples, ST001 (RM 1.9E) and ST003 (Multnomah Channel) during Quarter 1 of the 2006/7 sampling event. Dieldrin was detected upriver at ST009 (RM 15.7E) during both Quarters 3 and 4 of the 2006/7 sampling event, but was only detected downstream at ST003 (Multnomah Channel) during Quarter 4. There was not enough data to determine any relationship for aldrin and dieldrin between river reaches.

### **5.3.11 Arsenic in Sediment Traps Mobile Sediment**

#### **5.3.11.1 Arsenic Data Set**

Arsenic was detected in all 62 samples analyzed at concentrations ranging from 1.48 J mg/kg to 7.01 mg/kg (Figure 5.2-26 Tables 5.3-2 through 7).

#### **5.3.11.2 Arsenic Spatial and Temporal Evaluation in Study Area**

There was relatively little variation in concentrations among samples within the Study Area, with approximately 80 percent of the values ranging between 2.753 mg/kg and 7.016 mg/kg (Figures 5.3-18a-b).

The highest arsenic concentration was found at Station ST011 (RM 3.5E) during Quarter 4 of the 2006/7 sampling event. There was little difference between paired samples. The highest levels were generally found during Quarter 4, particularly downstream of RM 9, although Quarter 2 showed equally high levels in the upper Study Area (RMs 9.7-11.5).

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### 5.3.11.3 Arsenic Relationship by River Reach

Most concentrations of arsenic from Study Area stations were similar to or slightly above arsenic concentrations in upriver locations, except during Quarter 3. Arsenic levels in Study Area samples rarely varied from the arsenic levels at upstream stations by more than a factor of two. Downstream samples had similar concentrations to those in the Study Area, and were also generally greater than the upriver samples by a factor of two.

### 5.3.12 Chromium in Sediment Traps Mobile Sediment

#### 5.3.12.1 Chromium Data Set

Chromium was detected in all 62 samples analyzed at concentrations ranging from 16.8 mg/kg to 59.5 mg/kg (Figure 5.2-27 Tables 5.3-2 through 7).

#### 5.3.12.2 Chromium Spatial and Temporal Evaluation in Study Area

There was relatively little variation in concentrations among samples within the Study Area, with approximately 80 percent of the values ranging between 16.8 mg/kg and 47.1 mg/kg (Figures 5.3-19a-b).

The highest chromium concentration was found during Quarter 1 of the 2006/7 sampling event at Station ST01309 (RM 615.7E), the location furthest upstream. However, the highest concentrations within stations also tended to occur during Quarter 1. The only other sample collected within the Study Area greater than 40 mg/kg was at ST006 (Swan Island Lagoon) during Quarter 3 of the 2006/7 sampling event. The majority of the 2009 data set had concentrations less than 30 mg/kg. There were no locations with levels of chromium consistently higher than all others, and there was little difference in chromium concentrations between paired samples, and there was little variability between samples collected on either shore of the river.

#### 5.3.12.3 Chromium Relationship by River Reach

Although the highest chromium concentration was found in a sample ST009 (RM 15.7E) from an upstream in the upriver reach location during Quarter 3 of the 2006/7 sampling event, the majority of samples in this reach range between 30 and 40 mg/kg. Likewise, most chromium concentrations from Study Area stations were the same or slightly above chromium concentrations typically within the range of samples typically found in upstream the upriver reach locations. Downstream samples ranged from 16.8 mg/kg to 40.4 mg/kg with the majority of values also typically within the 30-40 mg/kg range. Chromium levels in Study Area samples rarely varied from average chromium levels at upstream stations by more than a factor of two.

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### 5.3.17.5.3.13 Copper in ~~Sediment Traps~~ Mobile Sediment

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#### 5.3.13.1 Copper Data Set

Copper was detected in all 62 samples analyzed at concentrations ranging from 15.2 mg/kg to 93.6 mg/kg (Figure 5.2-28 Tables 5.3-2 through 7). There was relatively little variation in concentrations among samples, with approximately 80 percent the majority of the values between 34 mg/kg and 58 mg/kg within a factor of 3.

#### 5.3.13.2 Copper Spatial and Temporal Evaluation in Study Area

The highest copper concentration was found at Station ST006 (Swan Island Lagoon) during Quarter 3 of the 2006/7 sampling event (Figures 5.3-20a-b). The second highest concentration (75.1 mg/kg) was found at the upstream location ST009 (RM 15.7E), also during Quarter 3. The highest concentrations among sampling periods per station often occurred during Quarter 4 of the 2006/7 sampling event, particularly at stations from RM 3.5 through 6.7. There was little difference in copper concentrations between paired samples. The majority of samples collected in Quarter 4 were greater than 50 mg/kg, while the majority of samples collected in other Quarters were generally between 30 and 50 mg/kg. All samples collected during the 2009 sampling event were less than 42.7 mg/kg. Samples greater than 50 mg/kg are noted from the 2006/7 sampling event during Quarter 1 at ST013 (RM 6.7E), during Quarter 2 at ST004 (RM 6.0E) and ST013 (RM 6.7E), during Quarter 3 at ST006 (Swan Island Lagoon) and ST011 (RM 3.5E), and during Quarter 4 at ST004 (RM 6.0E), ST005 (RM 6.0W), ST006 (Swan Island Lagoon), ST007 (RM 11.3E), ST011 (RM 3.5E), ST012 (RM 4.5W), and ST013 (RM 6.7E).

#### 5.3.13.3 Copper Relationship by River Reach

Although the second highest copper concentration was found in a sample from one of the upstream locations (ST009) during Quarter 3 of the 2006/7 sampling event, the majority of samples in this reach are less than 43 mg/kg. Most copper concentrations from Study Area stations were slightly above upriver copper concentrations in upstream locations collected during the same time period, except during Quarter 3, as mentioned above. Copper levels in Study Area samples rarely varied from the copper levels at upstream stations by more than a factor of two. Downstream samples ranged from 25.1 mg/kg to 52.4 mg/kg, which is similar to the majority of samples measured in the Study Area.

### 5.3.17.85.3.14 Zinc in ~~Sediment Traps~~ Mobile Sediment

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#### 5.3.14.1 Zinc Data Set

Zinc was detected in all 62 samples analyzed at concentrations ranging from 71.56 mg/kg to 319 mg/kg (Figure 5.2-29 Tables 5.3-2 through 7). There was relatively little variation in concentrations among samples, with approximately 80 percent of the values between 99 mg/kg and 170 mg/kg concentrations being within a factor of 3.

#### **5.3.14.2 Zinc Spatial and Temporal Evaluation in Study Area**

The highest zinc concentration was found during Quarter 3 of the 2006/7 sampling event at Station ST006 (Swan Island Lagoon). ST006 was the only station that appeared to contain comparatively high localized concentrations, although only -data from two quarters were available from this location. Among sampling periods (Figures 5.3-20a-b), the highest zinc concentrations per station most often occurred during Quarter 4 of the 2006/7 sampling event. Quarter 4 of the 2009 sampling event generally had the lowest zinc levels among sampling periods. ~~Samples from paired stations had nearly identical zinc concentrations during concurrent sampling periods, except for the relatively large difference between ST010 (RM 15.6W; 125 mg/kg) and ST009 (RM 15.7E; 71.6 mg/kg) during Quarter 4.~~ The majority of samples collected were less than 140 mg/kg. Samples greater than 140 mg/kg are noted from the 2006/7 sampling event during Quarter 2 at ST015 (RM 9.7W), during Quarter 3 at ST006 (Swan Island Lagoon) and ST011 (RM 3.5E), and during Quarter 4 at ST004 (RM 6.0E), ST005 (RM 6.0W), ST006 (Swan Island Lagoon), ST007 (RM 11.3E), ST011 (RM 3.5E), ST012 (RM 4.5W), ST013 (RM 6.7E), ST015 (RM 9.7W) and ST016 (RM 9.9E).

#### **5.3.14.3 Zinc Relationship by River Reach**

Most concentrations of zinc from Study Area stations were slightly above zinc concentrations in up~~river~~~~stream~~ locations, except during Quarter 3 of the 2006/7 sampling event. Zinc levels in Study Area samples rarely varied from the zinc levels at upstream stations by more than a factor of two during the same sampling period. Downstream samples ranged from 101 mg/kg to 160 mg/kg, with higher concentrations in downstream stations ST001 and ST002 during Quarter 4 of the 2006/7 sampling event. Samples collected downstream during Quarters 1, 2 and 3 and those collected in Multnomah channel are similar to the majority of samples measured in the Study Area, but slightly higher than upriver samples.

### **5.3.17.95.3.15 Tributyltin Ion in Sediment TrapsMobile Sediment**

#### **5.3.15.1 TBT Data Set**

TBT analysis was conducted for 60 sediment trap samples (Tables 5.3-2 through 7). TBT was detected in ~~approximately 80 percent~~46 of the samples analyzed ~~with—D~~ detectable concentrations of TBT ranging~~ed~~ from 0.48 J µg/kg to 81 µg/kg (~~Figure 5.2-30~~).

#### **5.3.15.2 TBT Spatial and Temporal Evaluation in Study Area**

TBT concentrations at ST006 (Swan Island Lagoon) during Quarters 3 and 4 of the 2006/7 sampling event, ~~for the only~~ two quarters that data were available for that station, and at ST001 during Quarter 3 of the 2009 data set were elevated an order of magnitude above other locations (Figures 5.3-21a-b). Concentrations within locations were generally highest during Quarter 4, and concentrations during all sampling periods

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were generally highest downstream of Swan Island Lagoon. The majority of samples collected were less than 5 mg/kg. Samples greater than 5 mg/kg are noted from the 2006/7 sampling event during Quarter 3 at ST004 (RM 6.0E), ST006 (Swan Island Lagoon), and ST014 (RM 7.5W, and during Quarter 4 at ST005 (RM 6.0W), ST006 (Swan Island Lagoon), ST007 (RM 11.3E), ST011 (RM 3.5E), and ST014 (RM 7.5W). The only sample greater than 5 mg/kg during the 2009 sampling event was during Quarter 3 at ST001 (RM 11.1). The median TBT concentration downstream of RM 9 was 3.8 µg/kg, with only one sample below the reporting limit (0.17 µg/kg, at ST005). Upstream of RM 9, the median TBT concentration was 0.48 J µg/kg, assuming non-detects equal zero, and nearly one-half of the samples were undetected at reporting limits of 0.12–0.87 µg/kg.

### **5.3.15.3 TBT Relationship by River Reach**

There was only one sample out of six in the upriver reach that was detected; the detected concentration was 1.9 mg/kg. All non-detect values in the upriver reach were below this value. Differences between paired samples were difficult to assess due to the number of non-detects. The largest observed within pair differences occurred at RM 6, where TBT concentrations from east side (ST004) samples were higher than those from the west side (ST005) during Quarter 1 (4.6 µg/kg vs. non-detect at 0.17 U µg/kg) and Quarter 2 (4.9 µg/kg vs. 1.5 J µg/kg). However, this situation was reversed during Quarter 4, with higher concentrations found at ST005 (13 µg/kg) compared to ST004 (3.9 µg/kg).

In general, TBT levels in the Study Area were higher than TBT level detecteds upstream of the Study Area in the upriver reach. However, since only one of six samples from ST010 (RM 15.6W) and ST009 (RM 15.7E) the upriver stations had a detectable TBT concentration, the degree of elevation upstream cannot be meaningfully quantified. Concentrations of TBT in the downstream reach were generally less than 4.3 mg/kg, with only one sample greater than 5 mg/kg noted during Quarter 3 at ST002 (RM 1.8W). Downstream TBT samples are notably less than the Study Area, but greater than the upriver reach.

### **5.3.18 Summary of Nature and Extent of Indicator Chemicals in Sediment Traps**

PCBs, PCDD/Fs, DDx, and PAHs were found in sediment traps throughout the Study Area and at upstream locations, with concentrations of each IC varying by two to three orders of magnitude. In general, samples with the highest IC concentrations were found in sediment traps located from RM 6 through RM 11.3. Specific locations with the consistently greatest PCB and PAH concentrations were easily distinguishable; it was less obvious if maximum PCDD/Fs and DDx consistently corresponded to specific locations over the course of the study.

Total PCB concentrations (as congeners) ranged from 3.14 J to 11,100 J µg/kg, with the highest PCB concentrations consistently found on the east side of the river at RM 11.3.

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Samples from RM 11.3E during low and medium flow periods (Quarters 2, 3, and 4) had total PCB concentrations elevated two to three orders of magnitude above those at other locations, with concentrations generally diminishing with distance downstream. Total PCB concentrations in sediment traps located above Ross Island (RM 15.6–15.7) were generally lower, with an overall median concentration one third of those from Study Area sediment traps.

For PCDD/Fs in sediment traps, it was more difficult to identify a distinct location with the highest total concentrations. Total PCDD/F homolog concentrations ranged from 5.16 J pg/g to 6,100 J pg/g, with the highest concentration found in the solitary sample from Swan Island Lagoon. There did not appear to be a consistent geographical gradient in PCDD/F concentrations, and intermittently elevated concentrations (relative to other samples) occurred at RM 11.3E, 1.8W, and 7.5W. Study Area samples had an overall median total PCDD/F concentration approximately 40 percent higher than the overall median of upstream samples.

Total DDX concentrations in sediment traps were also variable enough to preclude assigning the highest concentrations to a single location. Concentrations of total DDX ranged from 0.98 J µg/kg to 150 µg/kg, with the highest concentration found at RM 11.3E. However, the unusual composition of DDX in samples from RM 11.3E (100 percent 2,4'-DDD during Quarters 3 and 4) coupled with possible analytic interference from Aroclors calls into question the validity of the DDX results from this location. Like other ICs, total DDX was higher in Study Area samples, with an overall median concentration double that of upstream samples.

Total PAH concentrations at RM 6W were elevated an order of magnitude above most other locations. Concentrations of total PAHs ranged from 77 J µg/kg to 11,000 µg/kg and, in general, were highest at locations from RM 3 through RM 6, including Multnomah Channel. Although one sample from RM 15.6W had comparatively high total PAH concentrations during one of the sampling periods, the overall median concentration in Study Area samples was triple that of samples from upstream sediment traps.